AUSTRALIAN ANODISING ASSOCIATION

Environmental Impact Comparison of Fluoropolymer Powder Coating, Polyester Powder Coating and Anodising processes

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Report Number: KMH 4010213 Rev 0

PROJECT NUMBER: KMH 4010213					
DOCUMENT NUMBER: KMH 4010213 REPORT 101123					
REV	**DESCRIPTION**	**PREPARED BY**	**REVIEWED BY**	**APPROVED BY**	**DATE**
0	Report	SN	TT	GL	23/11/2010

LIMITATIONS STATEMENT

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1. INTRODUCTION

KMH Sustainable Infrastructure has been engaged to provide an Environmental Impact Assessment on the Anodising and Polyester Powder Coating processes. The Australian Institute of Surface Finishers (AISF) seek a review of the full life-cycle energy and environmental data available for Anodising, Fluoropolymer Powder Coating and Polyester Powder Coating. Much of the data has been developed from local industry information including association members. This data has been used to calculate energy consumptions for the various steps in the production of coated aluminium products, all on the basis of kilowatt-hours per tonne of aluminium product (kWh/tonne of Al), and the associated greenhouse gas (GHG) emissions in carbon dioxide equivalents per tonne of aluminium produced (CO_2-e/tonne of Al).

The whole product life-cycle assessment has been completed in accordance with the Australian Competition and Consumer Commission's (ACCC) *Green marketing and the Trade Practices Act* and includes the manufacturing, recycling, destruction and disposal process.[1] This document specifically recommends the use of whole product life-cycle as one of a number of principles to be followed when making claims about a particular product.

2. LIFE CYCLE ANALYSIS

The product Life Cycle Assessment (LCA) methodology uses actual figures, such as those for energy consumption, emissions to the environment and materials used for both the Anodising, Fluoropolymer Powder Coating and Polyester Powder Coating processes and for aluminium section primary production and recycle processes. This data is separated into stages of the life-cycle and all other factors considered are outlined in this review.

2.1. Primary Production of Virgin Aluminium

The life cycle of 1 tonne of surface coated aluminium begins with the primary production of virgin aluminium, a highly energy intensive process involving mining, shipping, refining and smelting, with major electric and fuel consumptions, as well as the considerable embodied energy in the chemicals used. This is followed by reheating and forming, including casting, forging, extrusion and rolling processes, to produce the sections and other products required. The surface coating process involves the use of chemicals, electricity, fuel and gas heating energy.

Electricity and gas consumption in terms of energy per tonne of aluminium production and GHG emissions per tonne of aluminium for both manufacturing processes are displayed in Table 1 for the Anodising process, Table 2 for the Fluoropolymer Powder Coating and Table 3 for the Polyester Powder Coating process. The process steps, including the manufacture of chemicals consumed, are separated into corresponding electricity, fuel and gas consumption figures per tonne of aluminium. Because Anodised, Fluoropolymer Powder Coated and Polyester Powder Coated products all involve the same primary production these energy figures have been omitted from the comparison.

2.2. Surface Coating Energy Consumption

KMH has obtained site specific energy and production data for the past 12 months from a total of three Anodising, Fluoropolymer Powder Coating and Polyester Powder Coating manufacturing process sites along the eastern seaboard of Australia, including a site visit in Victoria. Additional data has also been obtained from the Australian Aluminium Finishing (AAF) members. An average based on throughput (kWh/tonne of Al) of the three sites in Australia has been used to calculate Electricity and Gas consumption per tonne of Aluminium product. Production and performance data for the three processes was used to calculate energy consumption (kWh) and GHG emissions. Based on average production a figure of 2.3 – 2.4kg/m^2 or 0.426m^2/kg has been used.

[1] Australian Competition and Consumer Commission (ACCC) 2008, *Green marketing and the Trade Practices Act*, http://www.accc.gov.au/content/item.phtml?itemId=815763&nodeId=69646a6d15e7958a41b40ab5848c6968&fn=Green%20marketing%20and%20the%20Trade%20Practices%20Act.pdf

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2.3. Surface Coating Profile

Coating depth or 'thickness' is the principal energy affecting variable in the actual Anodising, Fluoropolymer Powder Coating and Polyester Powder Coating processes. Anodising coating thickness generally varies from 5 to 25 micron depending on the duty, and 20 micron has been assumed for the present exercise, this has been suggested as best representing the most frequently used product in Australia.

Fluoropolymer Powder Coating thickness generally varies from 2 to 50 micron depending on the duty, and 50 microns has been assumed as a comparable coating for the present exercise, again representing the most 'popular' product.

Polyester Powder Coating finish thickness to a large extent determines the useful life of the coating and following the Australian Standard 3715 (2002) for architectural applications a 60 micron coating has been employed for the present exercise.

2.4. Aluminium Recycling Energy Consumption

After the surface coating reaches the end of its functioning life, the aluminium can be recycled. This involves cleaning, melting, casting and then the forming processes. The recycled aluminium can then be re-coated through a repeat of the surface coating process.

Surface coated aluminium is fully recyclable along with its aluminium substrate without any loss of its metal qualities.

Recycling surface coated aluminium involves melting the scrap metal down. This process requires about five (5%) percent of the energy used to produce aluminium from ore. Recycling of aluminium emits approximately four (4%) percent of the CO_2-e as for primary production of aluminium.[2]

However, a significant part (up to 15% of the input material) is lost as dross (ash-like oxide). The dross can undergo a further process to extract aluminium. This complexity has not been included in the present considerations, it is highly energy intensive.

2.5. Surface Coating Life Expectancy

The estimated end of life for Anodised, Fluoropolymer Powder Coating and Polyester Powder Coated aluminium has been taken as 50, 40 and 25 years respectively. Anodised and Fluoropolymer Powder Coating years of serviceability have been provided based on reasonable evidence in industry.

The Japanese Society of Steel Construction Authority (2002) claim that the anti-corrosive effect of a heavy duty Fluoropolymer Powder Coating in general environment lasts up to 50 years[3]. A severe environment (very salty and severely polluted by exhaust gases or factory smog) is up to 30 years. The average of the two environments (40 years) has been assumed for this exercise and has been confirmed by the industry experience in Australia.

Architectural Polyester Powder Coating has a life expectancy standard of maximum 10% reduction in erosion resistance properties over 5 years[4]. The end of life for Polyester Powder Coated aluminium is assumed to be when 50% loss in erosion resistance properties has occurred. This is deemed to be a sufficient loss of thickness that factors such as dulled appearance, protective function and potential for corrosion cause the product quality to be sufficiently diminished that it is ready for replacement. Therefore, a 25 year life has been

[2] Subodh K.Das, Secat, Inc., 2007, 'Aluminium Recycling and Processing for Energy Conservation and Sustainability', Chapter 9, *Emerging Trends in Aluminium Recycling*.
[3] Lumiflon catalogue 'Fluoropolymer for coating', http://www.alpolic-usa.com/media/download_gallery/Lumiflon_Catalogue.pdf
[4] Taken from AAMA coating performance standard AAMA 2604-05.

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estimated for Polyester Powder Coated aluminium based on the life expectancy standard of 10% in erosion resistance properties every 5 years.
A 100 year life cycle has been chosen to represent a reasonable life cycle assessment. For a 100 year life cycle, the Anodised aluminium will be recycled once and go though the anodising process twice. Fluoropolymer Powder Coating will be recycled two (2) times and coated three (3) times. Polyester Powder Coated aluminium over a 100 year life cycle will be recycled a total of three (3) times and coated four (4) times.

Totals in Table 1, Table 2 and Table 3 can be used to look at alternative life cycle years. These totals are annual amounts that can be multiplied by the number of coatings and recycles that will occur in the investigated life cycle period.

2.6. Emission Factors

The emission factors for electricity, gas and diesel oil (fuel) consumed in the LCA come from the Department of Climate Change workbook *National Greenhouse Accounts (NGA) Factors (June 2009)*[5]. Due to variability in emission factors between Australian States and Territories, New South Wales (NSW) and Australian Capital Territory (ACT) have been used to estimate a point of reference of emissions to the environment. Any use of the present study results needs qualification with respect to the energy emission factors employed in the study. It is likely that the variations from state to state will affect the results to a large degree, but it is certain that any comparisons of emission factors will still favour Anodising as the more energy efficient alternative.

For electricity consumption, the full fuel cycle emission factors were utilised. These consist of Scope 2 (Indirect) (0.89 kgCO_2-e/kWh) and Scope 3 (0.18 kgCO_2-e/kWh) emission factors for consumption of purchased electricity from the grid.

The full fuel emission factors for natural gas distributed in a pipeline include both Scope 2 (indirect) (51.33 kgCO_2-e/GJ) and Scope 3 (16.4 kgCO_2-e/GJ). For NGA calculations, a “small user” has been assumed and is defined as one with an annual gas consumption of less than 100,000 GJ.

The Diesel oil full fuel emission factors for the “fuel” used in the production and chemical process include both Scope 1 (direct) (69.5 kgCO_2-e/GJ) and Scope 3 (5.3 kgCO_2-e/GJ).

In Australia, electricity from the grid in NSW and ACT has the second highest emission factor (full fuel cycle) 1.07 kgCO_2-e/kWh after Victoria 1.35 kgCO_2-e/kWh. Tasmania is the lowest at 0.24 kgCO_2-e/kWh with Northern Territory the next lowest at 0.79 kgCO_2-e/kWh.

Scope 3 emission factors (small user) for Natural gas from NSW and ACT are the highest in Australia at 16.4 kgCO_2-e/GJ. South Australia is 13.9 kgCO_2-e/GJ and all other States and Territories are less than 5 kgCO_2-e/GJ.

2.7. Alternative Energy Emission Factors

Energy efficiency measures and alternative forms of energy can have a strong impact on improving the environmental impact of all three investigated processes. Energy efficiency can also potentially reduce overall costs. The reduction in energy consumption throughout the life-cycle will directly reduce the amount of GHG emissions produced. Alternative forms of energy with a lower emission factor may also reduce the environmental impact. The energy content factor (GJ/kL) of the alternative fuel and its source of origin is used to determine the feasibility of reducing emissions with regards to the volume of fuel combusted and energy used for transporting or supplying the fuel.

[5] Department of Climate Change 2009, National Greenhouse Accounts (NGA) Factors, http://www.climatechange.gov.au/~/media/publications/greenhouse-gas/national-greenhouse-factors-june-2009-pdf.ashx

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Table 1 Anodising energy consumption and GHG footprint

Aluminium Primary Manufacture (Anodising)	Energy Consumption (kWh/kg of Al)	Average Energy Consumption (kWh per tonne of Al)	GHG emission factor ($kgCO_2$-e/kWh)	Annual GHG footprint (TCO_2-e per tonne of Al)
Total Mining, refining, smelting and transport (Elec.)	43.6 - 50.3	46,944	1.07	50.23
Total Mining, refining, smelting and transport (Fuel)	11.1	11,111	0.27	2.99
Casting processes (Electricity)	0.4 - 0.5	431	1.07	0.46
Casting processes (Fuel)	0.2	222	0.27	0.06
Forging/rolling/extrusion (Electricity)	0.6 - 0.9	778	1.07	0.83
Forging/rolling/extrusion (Fuel)	0.3	333	0.27	0.09
Conventional machining (Electricity)	0.9 - 1.1	1,042	1.07	1.11
Conventional machining (Fuel)	0.5	528	0.27	0.14
TOTAL		**61,389**		**55.9**
Anodising Chemicals	**Energy Consumption (kWh/kg)**	**Annual Energy Consumption (kWh per tonne of Al)**	**GHG emission factor ($kgCO_2$-e/kWh)**	**Annual GHG footprint (TCO_2-e per tonne of Al)**
NaOH (Electricity)	2.1 - 2.9	237	1.07	0.0027
NaOH (Fuel)	1.5	85	0.27	0.0004
HNO3 (Electricity)	-0.09	-14	1.07	0.0001
HNO3 (Fuel)	0	0	0.27	0
H3PO4 (Electricity)	0.6 to - 0.7	-15	1.07	0.0007
H3PO4 (Fuel)	1.1	26	0.27	0.0003
H2SO4 (Electricity)	-0.27 to - 0.33	-130	1.07	0.0003
H2SO4 (Fuel)	0	0	0.27	0
Nickel Acetate Seal: Sealing (hot or cold) (including mining and refining) (Electricity)	2.8 - 5.6	2	1.07	0.0045
Nickel Acetate Seal: Sealing (hot or cold) (including mining and refining) (Fuel)	8.3	3	0.27	0.0022
TOTAL		**194**		**0.011**
Recycle: Melting (energy used to recycle aluminium at the end of life (50 years) is 5% of the energy used to produce aluminium from ore and only 4% as much CO_2-e as primary production)		3,069		2.237
Anodising Process: Electricity and Gas		**Energy usage per tonne production (kWh/tonne of Al)**	**GHG emission factor ($kgCO_2$-e/kWh)**	**Annual GHG emissions (TCO_2-e per tonne of Al)**
Electricity		1529.7	1.07	1.64
Gas		1910.9	0.24	0.47
TOTAL		**3,440.6**		**2.10**

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Table 2 Fluoropolymer Powder Coating energy consumption and GHG footprint

Aluminium Primary Manufacture (Fluoropolymer Powder Coating)	Energy Consumption (kWh/kg of Al)	Average Energy Consumption (kWh per tonne of Al)	GHG emission factor (kgCO_2-e/kWh)	Annual GHG footprint (TCO_2-e per tonne of Al)
Total Mining, refining, smelting and transport (Elec.)	43.6 - 50.3	46,944	1.07	50.23
Total Mining, refining, smelting and transport (Gas)	11.1	11,111	0.27	2.99
Casting processes (Electricity)	0.4 - 0.5	431	1.07	0.46
Casting processes (Gas)	0.2	222	0.27	0.06
Forging/rolling/extrusion (Electricity)	0.6 - 0.9	778	1.07	0.83
Forging/rolling/extrusion (Gas)	0.3	333	0.27	0.09
Conventional machining (Electricity)	0.9 - 1.1	1,042	1.07	1.11
Conventional machining (Gas)	0.5	528	0.27	0.14
TOTAL		**61,389**		**55.9**
Fluoropolymer Powder Coating Chemicals	**Energy Consumption (kWh/kg)**	**Annual Energy Consumption (kWh per tonne of Al)**	**GHG emission factor (kgCO_2-e/kWh)**	**Annual GHG footprint (TCO_2-e per tonne of Al)**
Pre-treatment: Pre-cleaner - **HF** (including mining and refining of fluorspar and heating of kilns) (Electricity)	2.8 - 5.6	49.6	1.07	0.0045
Pre-treatment: Pre-cleaner - **HF** (including mining and refining of fluorspar and heating of kilns) (Fuel)	8.3	99.3	0.27	0.0022
Pre-treatment: Pre-cleaner - **H2SO4** (Electricity)	-0.28 to -0.33	-2.4	1.07	0.0003
Pre-treatment: Pre-cleaner - **H2SO4** (Fuel)	0	0.0	0.27	0
Pre-treatment - **HF** (Electricity)	2.8 - 5.6	2.0	1.07	0.0045
Pre-treatment - **HF** (Fuel)	8.3	4.0	0.27	0.0022
Pre-treatment - **H2CrO4** (Electricity)	3.9 - 5.6	10.4	1.07	0.0051
Pre-treatment - **H2CrO4** (Fuel)	10.0	22.1	0.27	0.0027
Powder – **Polymer** (30%-60%) (Electricity)	19.4 - 20.8	78.1	1.07	0.0215
Powder – **Polymer** (30%-60%) (Fuel)	9.7	37.7	0.27	0.0026
Powder – **Pigment** (30%-60%) (Electricity)	22.2 - 26.1	93.7	1.07	0.0259
Powder – **Pigment** (30%-60%) (Fuel)	11.1	43.1	0.27	0.0030
TOTAL		**438**		**0.07**
Recycle: Melting (energy used to recycle aluminium at the end of life (40 years) is 5% of the energy used to produce aluminium from ore and only 4% as much CO2-e as primary production)		3,069		2.237
Fluoropolymer Powder Coating Process: Electricity and Gas		**Energy usage per tonne production (kWh/tonne of Al)**	**GHG emission factor (kgCO_2-e/kWh)**	**Annual GHG emissions (TCO_2-e per tonne of Al)**
Electricity		247.9	1.07	0.27
Gas		3269.2	0.24	0.80
TOTAL		**3,517.1**		**1.06**

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Table 3 Polyester Powder Coating energy consumption and GHG footprint

Aluminium Primary Manufacture (Polyester Powder Coating)	Energy Consumption (kWh/kg of Al)	Average Energy Consumption (kWh per tonne of Al)	GHG emission factor ($kgCO_2$-e/kWh)	Annual GHG footprint (TCO_2-e per tonne of Al)
Total Mining, refining, smelting and transport (Elec.)	43.6 - 50.3	46,944	1.07	50.23
Total Mining, refining, smelting and transport (Gas)	11.1	11,111	0.27	2.99
Casting processes (Electricity)	0.4 - 0.5	431	1.07	0.46
Casting processes (Gas)	0.2	222	0.27	0.06
Forging/rolling/extrusion (Electricity)	0.6 - 0.9	778	1.07	0.83
Forging/rolling/extrusion (Gas)	0.3	333	0.27	0.09
Conventional machining (Electricity)	0.9 - 1.1	1,042	1.07	1.11
Conventional machining (Gas)	0.5	528	0.27	0.14
TOTAL		**61,389**		**55.9**
Polyester Powder Coating Chemicals	**Energy Consumption (kWh/kg)**	**Annual Energy Consumption (kWh per tonne of Al)**	**GHG emission factor ($kgCO_2$-e/kWh)**	**Annual GHG footprint (TCO_2-e per tonne of Al)**
Pre-treatment: Pre-cleaner - **HF** (including mining and refining of fluorspar and heating of kilns) (Electricity)	2.8 - 5.6	49.6	1.07	0.0045
Pre-treatment: Pre-cleaner - **HF** (including mining and refining of fluorspar and heating of kilns) (Fuel)	8.3	99.3	0.27	0.0022
Pre-treatment: Pre-cleaner - **H2SO4** (Electricity)	-0.28 to -0.33	-2.4	1.07	0.0003
Pre-treatment: Pre-cleaner - **H2SO4** (Fuel)	0	0.0	0.27	0
Pre-treatment - **HF** (Electricity)	2.8 - 5.6	2.0	1.07	0.0045
Pre-treatment - **HF** (Fuel)	8.3	4.0	0.27	0.0022
Pre-treatment - **H2CrO4** (Electricity)	3.9 - 5.6	10.4	1.07	0.0051
Pre-treatment - **H2CrO4** (Fuel)	10.0	22.1	0.27	0.0027
Powder – **Polyester** (30%-60%) (Electricity)	19.4 - 20.8	93.7	1.07	0.0215
Powder – **Polyester** (30%-60%) (Fuel)	9.7	45.2	0.27	0.0026
Powder – **Pigment** (30%-60%) **Bulk TiO2 for white colour** (Electricity)	22.2 - 26.1	112.4	1.07	0.0259
Powder – **Pigment** (30%-60%) **Bulk TiO2 for white colour** (Fuel)	11.1	51.7	0.27	0.0030
TOTAL		**488**		**0.07**
Recycle: Melting (energy used to recycle aluminium at the end of life (25 years) is 5% of the energy used to produce aluminium from ore and only 4% as much CO2-e as primary production)		3,069		2.237
Polyester Powder Coating Process: Electricity and Gas		**Energy usage per tonne production (kWh/tonne of Al)**	**GHG emission factor ($kgCO_2$-e/kWh)**	**Annual GHG emissions (TCO_2-e per tonne of Al)**
Electricity		247.9	1.07	0.27
Gas		2335.1	0.24	0.57
TOTAL		**2,583.1**		**0.83**

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Table 4 and Figure 1 show the life cycle energy consumption per tonne of aluminium production for the Anodising and Polyester Powder Coating processes. The life cycle is based on 100 years with Anodising and Polyester Powder Coating life cycles being 50, 40 and 25 years respectively. The processes are separated into the chemicals, electricity, and gas consumption and recycling process. The primary production of aluminium is a large amount and is only used for the calculation of energy and GHG emissions in the recycling process (see Section 2.4 Aluminium Recycling Energy Consumption).

Table 4 Energy used for production of 1 tonne of surface coated aluminium (100 year life cycle) (kWh per tonne of Al produced)

Process	Chemicals and processing energy (including Al original production and recycling)	Chemicals and processing energy (including recycling)	Chemicals	Electricity	Gas	Recycling
Anodising (50 year life)	71,728	10,339	388	3,059	3,822	3,069
Fluoropolymer Powder Coating (40 year life)	79,392	18,003	1,313	744	9,808	6,139
Polyester Powder Coating (25 year life)	82,882	21,493	1,952	992	9,341	9,208

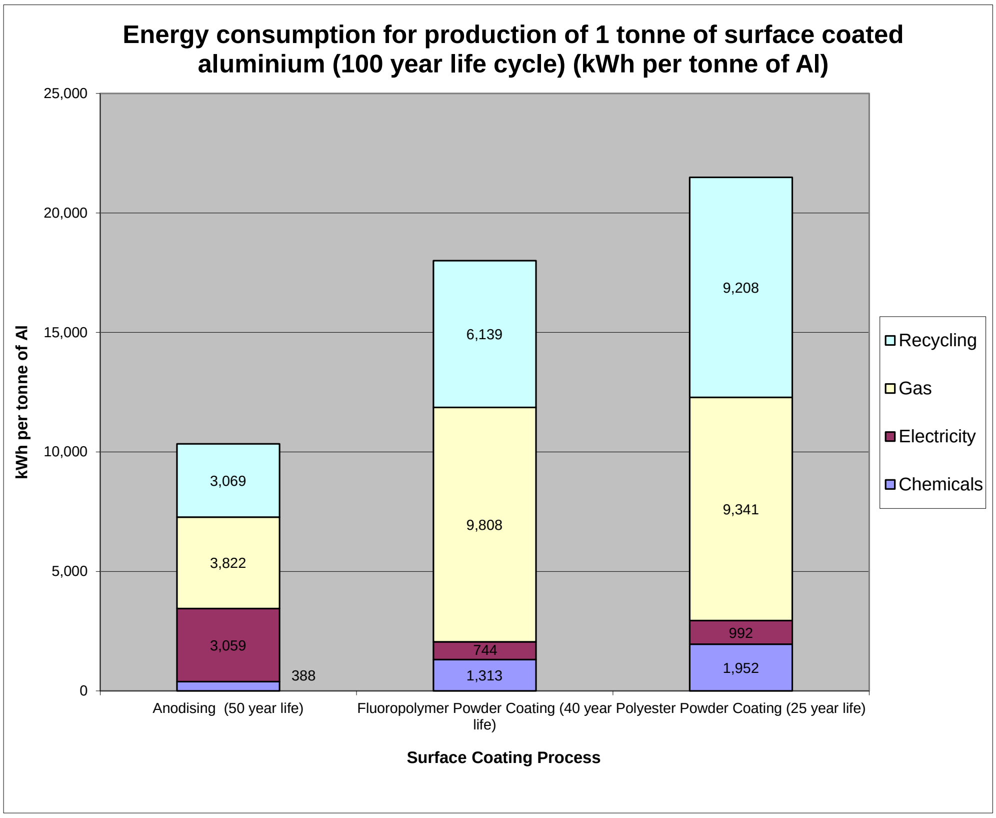

Figure 1 Energy use (100 year life cycle) for production of 1 tonne of surface coated aluminium

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Table 5 and Figure 2 show the GHG footprint, tonnes of CO2-e per tonne of aluminium production for the Anodising, Fluoropolymer Powder Coating and Polyester Powder Coating processes. The same life cycle of 100 years has been used to estimate the GHG emissions. The primary production of aluminium is a high value and only used to calculate the emissions in the recycling process (see Section 2.1 Recycling).

Table 5 GHG footprint for production of 1 tonne of surface coated aluminium (100 year life cycle) (tCO_2-e per tonne of Al produced)

Process	Chemicals and processing energy (including Al original production and recycling)	Chemicals and processing energy (including recycling)	Chemicals	Electricity	Gas	Recycling
Anodising (50 year life)	62.4	6.5	0.02	3.3	0.9	2.2
Fluoropolymer Powder Coating (40 year life)	63.8	7.9	0.22	0.80	2.4	4.5
Polyester Powder Coating (25 year life)	66.3	10.3	0.30	1.06	2.3	6.7

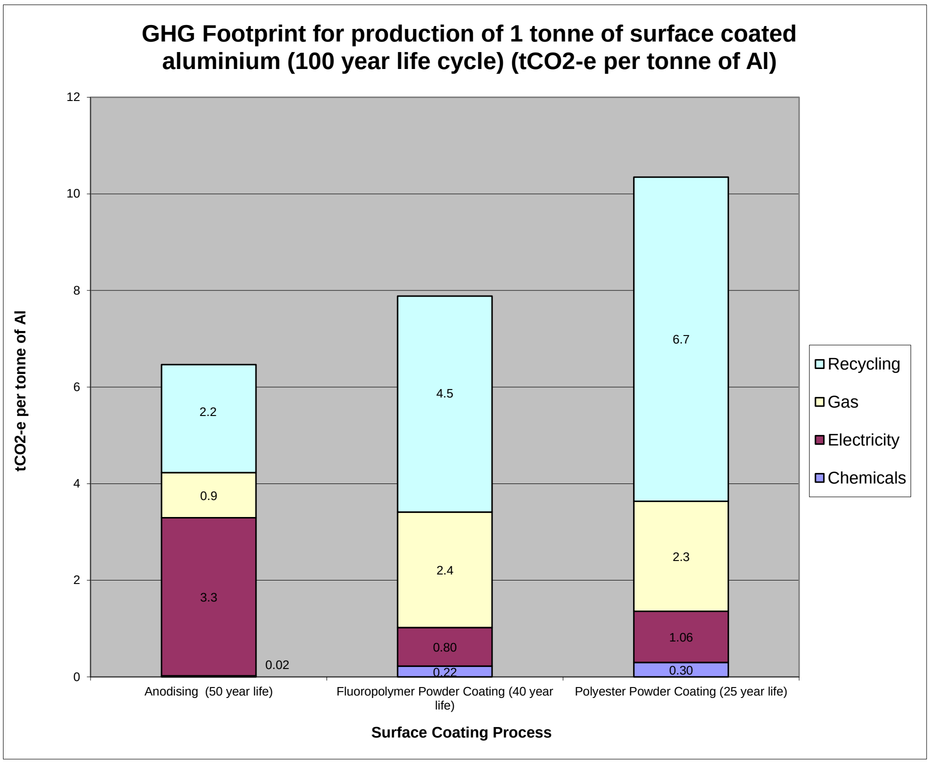

Figure 2 GHG footprint for 100 year life cycle production of 1 tonne of surface coated aluminium

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3. SUMMARY AND CONCLUSION

The present study is an energy and carbon footprint comparison aimed at providing the Association with a more representative answer to a published criticism of Anodising in comparison with Polyester Powder Coating and subsequently compared to Fluoropolymer Powder Coating. This study has focused on the energy consumption and related environmental impact this has on the environment.

From the results of the 100 year Life Cycle Analysis (LCA), Anodising is better both in terms of energy used (kWh) and greenhouse gas (GHG) emissions (CO_2-e) per tonne of aluminium product. Over a 100 year life cycle Polyester Powder Coating has almost double the energy component of the Anodising process and Fluoropolymer Powder Coating has approximately 45% more total energy component than the Anodising process.

In this LCA, Anodising has been apportioned a longer cycle life (50 years) and is therefore recycled less and uses less gas fuel and chemicals in the 100 year life cycle compared to the Fluoropolymer Powder Coating (40 year life) and Polyester Powder Coating (25 year life) process. However, the Powder Coating processes use significantly less in the way of direct electricity consumption over the same life cycle, but there is large energy embodiment in the chemicals and polymers used.

The lower energy consumption in recycling, chemicals and gas for Anodising corresponds to lower GHG emissions (CO_2-e) than Fluoropolymer Powder Coating and Polyester Powder Coating. However, a major proportion (~50%) of the GHG emissions for the Anodising process is from the consumption of electricity. Compared with the Polyester Powder Coating process, the overall GHG emissions for Anodising amount to 38%, or 3.9 tCO2-e less, per tonne of aluminium. Compared with the Fluoropolymer Powder Coating process, associated GHG emissions are only 18%, or 1.4 tCO2-e less, per tonne of aluminium.

The surface treatment employed generally depends on the end-use or application. Anodised products are best suited to storefronts, high-rise and commercial and public buildings, anywhere a rich metallic appearance and long life is required. The corrosion protection afforded by Anodising requires tight specification and control to ensure the correct Anodised film thickness is obtained and that sealing efficiency is high, to maintain corrosion resistance and colour life. Fluoropolymer Powder Coating is also used on commercial, industrial and residential buildings due to the high durability, adhesion, colour and gloss retention based on the fluorinated ethylene vinyl ether (FEVE) and carbon to fluorine atom (C-F) bond energy.

Environmental impact assessments of the coating processes will continue to be an important factor in the decision making process and there are many more environmental factors than energy and GHG carbon footprint. Some of the chemicals used require considerable discharge and emission control. These considerations in order to determine the full environmental impact warrant further study.

The consumption data was prepared from separate Anodising and Polyester Powder Coating operations in three states along the eastern seaboard of Australia. The plants offered differing technologies and products, yielding differing data. Averages of the sites for each of the products have been used in producing the figures presented in this report.

The range of energy levels across the various sites for the Anodising process are from 3,185 kWh/tonne of aluminium to 3,740 kWh/tonne of aluminium, an average of approximately 3,441 ±8%.

The range of energy levels from the Powder Coating process are higher with energy consumption from 2,127 kWh/tonne of aluminium to 3,137 kWh/tonne of aluminium, an average of approximately 2,583 ±20%.

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In addition, due to variations in emission factors for power generation across Australian States and Territories GHG emissions can vary depending on where the energy is sourced. However, it is certain that any comparisons of emission factors will still favour Anodising as the more energy efficient alternative. Similar charts could be produced covering the limiting cases.

The 100 year life cycle for surface coated aluminium employed in this LCA seems a reasonable basis for an end of recycle life, it could be longer, but with recycle losses and wastage this has been decided upon for present purposes. The longer the LCA period the greater the margin between the three aluminium surface finishing processes.

Many factors are involved in the overall environmental performance of a surface finishing process. Besides assessing the scenarios for energy consumption and the associated GHG emissions, energy efficiency measures and an increased use of renewable forms of energy can further reduce the CO_2-equivalent emissions for all aluminium surface finishing processes, some may be better than others.

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